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Addressing food security for worldwide megatrends

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Abstract

Till 2050, we will have to feed the 9 billion people with decreasing natural resources. Here, we connect the global food demand for future with the aspect of food science and agriculture in producing food to feed global population. Agriculture and food systems challenges including both crop and livestock production have presented in terms of global megatrends coupled with growing threat of climate change. Various opportunities and methods are discussed for reduction of food waste and food loss, and recovering the wasted product, can be consumed as innovative raw component in the food industries. In context of global mega trends, system-based perception links food security to crop productivity, food safety, nutritive and healthy intake, efficient value and supply chains. Article call for a multidisciplinary and synergetic approach to the food security science, with an emphasis in empowering techniques and upgrading technologies in context of social and global market trends to attain food security.

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Introduction

The present study focuses on the food security challenges and global megatrends. This study also provides the outlining of global megatrends in food security to mitigate the challenges.

Food security

Food security challenge against global megatrends

Sustainability, food security, feed the worldis the considerable challenge in the future (McGuire, 2015). The demand for food has been multiplying with the prominent increase in population during recent decades. The challenge of fulfilling the needs of food required a research based collective effort by various concerned departments; industry, academia and government. Furthermore, the advances in technology and techniques paved the way for productive outcomes in farming and the environment experienced subtle but visible changes (Sharma *et al.,* 2019; Aschemann *et al.,* 2019). The need of the hour is to plan and research over the increasing population as well as food consumption. The statistical figure exhibit that we need to have 70% more food for the survival of humanity till 2050.A megatrend can be defined as a considerable change in socio economic paradigm, environment, technology or political conditions that can redesign how a sector operates (Butler *et al.,* 2015).

Outlining the solution for food security

The pace of developing agricultural technologies along with other advances and innovations resulted in the form of reduction of waste, increased production of crops and decreased environmental effects (Foley *et al.,* 2011). Aschemann *et al.,* (2019) framed model for wedges and calories requirement for the rising population of world. Keeping in view the reduction of demand, fulfilment of production gap and setting aside the losses from the current production level, they recommended new methods to manage food security. Science and technology brings into light the concept and value of wedges that are required to ensure ample food availability in the market using limited resources. The idea is intended to enlighten the globally appreciated megatrends in farming technologies to develop collaborative and competitive environment.

Exposing pathways to decrease the food waste and food loss during marketing process

Although the increase in production plays its role in food security but the minimizing the food waste and loss can extra add to the ultimate total of production which may safely fulfill the food requirements. Decrease in food mass at production, harvesting, post-harvesting or value addition stages is termed as food loss while decrease of food during marketing process or consumption is referred as wastage of food (Gustavsson *et al.,* 2011). The comparative analysis of statistical data justifies observable difference in food loss and food waste on the basis of regions. Waste and loss of food happens during marketing or consumption in developed countries while in developing countries it occurs at production, harvesting, post-harvesting or value addition stages (Fox and Fimeche, 2013).

In order to attain nutritional and food security, food science and technology is of paramount importance (Augustin *et al.,* 2016). The developments and innovations in the processes of preservation and stabilization have extended the shelf life of various food items and it has eased the access of food products (Martindale, 2017).The loss of fresh products can be decreased by implementing effective post-harvest technologies. These practices have developed certain directions to carry the agricultural products from rural areas to megacities. This strengthens the food flow and sustainable food security by optimizing its distribution, improving access to proper transportation means, infrastructure development, management in marketing practices and management in value addition.

New technologies have been developed regarding food processing like use of ultrasound can enhance the extraction of oil from biomass (Chemat *et al.,* 2017).Separation and fermentation technologies are being used for natural preservation of food like forward osmosis technologies are being implemented to develop new ingredients and bio-actives from food waste (Hugenholtz, 2013). Recovering and rescuing food waste and food loss is the preferred way of increasing food security.

There are various countries in the world where food banks have been made in order to increase its shelf life and redistribute hygienic food to vulnerable groups. Such measures are the gateway to decrease food waste and it also determines to bring down food insecurity. This competitive environment may inspire various players who want to rectify the drawbacks found in the economic and environmental circles in terms of food wastage. Keeping in view all the said details, a multidimensional approach is required that could invite multi-stake-holder perspective. This will help ensure production and consumption of required food supply and develop a win-win solution for all stakeholders (Mourad, 2016).

The consumer's interest lies in the transparent environmental factors as well as smooth availability of food. It is the technology that has eased the access to information about various factors influencing food security. The collective correspondence of all the machinery will enhance the capacity of production and sustainable supply chains. Development of strong link among real-time analytics and all the digital platforms in order to make right decisions can lead to decrease in food loss (Petkovic *et al.,* 2017). Presently, a huge amount of food loss and wastage along with byproducts, straws, stems and leaves are value added to make feed for animals, chemicals production and energy.

Reducing diet over consumption by humans

The mechanism of being futuristic in terms of food demand as well as calories intends effective communication for proper stabilization process. Also, it is the need of the hour to focus on food demand to deliver required diet that may help us achieving the desired goals (Peters *et al.,* 2016 and Ridoutt *et al.,* 2017).For improvement replace ton per hectare yield, new metrics like nutritional yield has been introduced to consider the significance of food demand for sustainable production of agricultural products (DeFries *et al.,* 2015). Small farmers who create diversity in the provision of nutritious food may not be able to benefit from hybrid seeds and genetically modified seeds (Herraro *et al.,* 2017).

The demand of food for growing population has made the nutritional food security more intricate whereas twenty million people are already overweight. Food security can be enhanced by controlling over consumption by population without negative effects on environment. Various diet plans are available which are strongly recommended but they may not be followed. Availability of hygienic foods combined with change in consumer's behavior through education can help to fulfill the requirements (Lewis and Burton-Freeman, 2010).

This will create a chance to utilize system approach towards food security by managing food supply chain to meet the personal nutritional needs considering environmental impacts (Porter *et al.,* 2019). The innovations on molecular basis in terms of nutrition and obesity will give comprehensive directions marking health and wellness. For instance, epi-genetics plays an appreciable role in connection with obesity (Van Dijk *et al.,* 2015). Advancements in statistical data analyzingare proposing new ways to connect new epigenetics bio-markers, nutritional metabolomics, nutrigenomics and nutritional proteomics to agri. genomics in more cohesive methodology for personated nutrition (Özdemirand and Kolker, 2016).

Even if the consumers are provided with complete diet plan and updated information in food choices, yet they may not be in position to avail healthy food choices. Multiple factors are involved in controlling the food choices and plans i.e. sensory properties, cognitive factors, the feelings of satiety and neural control of appetitive behaviors (Schneider *et al.,* 2013 and Chambers *et al.,* 2015).A multidisciplinary integrated approach is needed to develop locally liked foods with optimum choices of healthy foods for different ethnicities (e.g. Kosher foods and Halal).

Livestock component rebalancing of the future diet

Sustainable foods should rescue environment and biodiversity, balance natural resources, be ethnically suitable, affordable and accessible to different type of populations and all at the same time should be nutritious and safe(Johnston *et al.,* 2014).The upward mobility of middle class and change in diet plan leads to upsurge in demand of livestock product. However, variation is found in land capacity to carry various diets like meat (Peters *et al.,* 2016).Various developed countries of the world have decreased meat consumption to reinstate biodiversity and bring compatibility with climate change (Stoll-Kleemann and Schmidt, 2017).

Although, the motivation to avoid from meat protein is available in the form of sustainability yet the tendency to reduce meat consumption has not been observed by the consumers (Hartmann and Siegrist, 2017).Meat may be produced feasibly by In-vitro culture technique but it is expensive at present. Additionally, the technology faces constraints due to social unacceptance.

The challenge of meat consumption with increasing population requires new reforms in the prevalent system of protein production. Cereals stay at top whereas pulses are also getting prominence in fulfilling the required production of proteins. Pulses can be used as source of proteins, micronutrients and fibers and these can be able to maintain the sustainability of meat consumption as well. Furthermore, algal biomass is another significant source of protein which can be recycled but at present the industry cannot afford its continuous implications (Henchion *et al.,* 2017). Besides this, the protein taken from improved sea-based plants may also enrich the process of meat sustainability in future.

In addition to this, insects are also great source of proteins as food and feed. For long term sustainability, a low cost and economical system of edible insects' production is required (van Huis and Oonincx, 2017).Insects are being consumed by some people from South America and China but it is prohibited in western countries on the basis of culture and religion. Improved marketing process of edible insects compatible to different cultures and communities of the world may also help to change the mindset of people (Tan *et al.,* 2017).

Developing smart biofuel policies

Doffing use of 1st generation biofuels (feed stocks i.e. sugarcane, corn, etc.) and adopting use of 2nd generation biofuels (cellulosic material) might reduce tension between fuel or food use (Chen and Smith, 2017). The concerns between food, land, energy and the diverse end-use of agricultural crops are of great importance than fuel versus food discussion, so their interdependence should be considered while developing policies regarding land use (Tomei and Helliwel, 2016).Biofuels may be produced from the non-eatable portions of plants by using latest technologies. Usually, oils are not produced at significant levels in leaves but latest technology permits plants to generate oil in leaves at significant levels, which also can offer a source of biofuel (Vanhercke *et al.,* 2017).

Revealing pathways to enhance production of food

There's dire need to design vigorous adaptation policies to combat with risk involved while sustaining and enhancing food production for the masses in coming future (Abdullah *et al.,* 2016).

Increasing the land resources

Limited options are available to unlock the new arable land. It is necessary to introduce new infrastructure to initiate reforms in new land and this can be achieved by avoiding the loss of transpiration. The considerable dropdown in water table over the last many years has massively degraded the productive environment. Climate change and deforestation with increasing urbanization affect evapotranspiration from soil with greater effect of climate change as compared to deforestation (Li *et al.,* 2017).

Water resources management for irrigation: Water safety has become aninclusiveconcern for the globe. Upgraded system for estimatingmoisture in soil, requirement of water for crops and effective usage of water for irrigation can be attained by relating weather forecasting and latest technology based data of hydrological modelling, environmental monitoring and earth observing (Ravazzani *et al.,* 2017). Real-time smartphone applications for irrigation and sensors for detecting soil water are also being used to provide assistance for optimum irrigation forecast (Migliaccio *et al.,* 2015). These advances in technology are playing an important role for precision irrigation and conserving water and maximizing its usage efficiency.

Growing aquaculture production

Aquaculture is the most competitive and lead growing sector in the world with respect to animal food production now a days. It is aquaculture that may help to attain current per capita consumption challenge and growing requirement of aquatic food for an additional forty million tons by 2030 (Ye *et al.,* 2017). Shift from fish-based foods towards plant based foods and environment friendly development that reduces effects on coastal ecosystems are sustainable production practices of aquaculture. Improved technologies are needed for intensive aquaculture to alleviate mortalities due to diseases. These technologies involve screening of disease in hatchlings, increased tolerance against disease, production of better feeds and improvement in production ponds and nearby environment (Diana, 2009).

Aquaculture is economical and useful at coastal areas but simultaneously it proves very harmful and risky for biodiversity, environment and coastal communities (Polidoro *et al.,* 2010). Indoor extensive recirculating systems of aquaculture decrease the probabilities of risk pertinent to outdoor aquaculture. The land-based commercial operations are very expensive which are used for salmon and rainbow trout production. Besides this, research in developing new techniques and technologies in the use of aquaponics systems will stabilize the culture of various species for desired clienteles (Dalsgaard *et al.,* 2013).

Abridging gaps in current livestock and agriculture production systems

It is probable to decrease the gap between possessed and potential yield that is visible in the current production systems of crops and livestock (Carfagna *et al.,* 2018). The progressive system of production should be synchronized with the adoption and development of latest farming technologies and techniques. Precision agriculture helps to introduce advance digital technologies that will bring integration of controlled fertilization, insect pest management, improved genotypes of crops and livestock, use of soil enrichment techniques and climate and weather forecasting. Development of models to attain reliable estimations of magnitude, temporal and spatial variability of will assist to find out utilizable yield gap which is footstep towards alleviation the gap in yield (Hochman *et al.,* 2013).

Increase inyieldwill be propped up through modified genetics couturier to crop production techniques and technologies. Better genetic prospective will be attained by picking genotypes for several traits likeoptimal utilization of resources, resistant towards abiotic and biotic hassle, implementation of directed biotechnology and instruments to increase improvement in ecological and phenol typing characterization. Packages of novel technology will be enabled by developments in technologies and techniques regarding timely sowing, integrated pest management, weather forecasting, ICTs, soil sensing and weather monitoring (Kirkegaard and Hunt, 2010 and Robertson and Murray,2016).It is evident that yield gaps can be reduced by effective management whereas use of genetically modified crops can further lead to increased yields. The emphasis on better and effective use of radiation forbreakdown photosynthetic to maximum.

Evolving farming systems with optimal use of land and water

Improvement in irrigation application will help to boost crop yield globally. It is only possible when system of irrigation is expanded by decreasing water consumption and using improved technology of water management (MacDonald *et al.,* 2016).This involves use of technologies and techniques to decrease evaporation from soil, to enhance capacity and efficacy of soil infiltration and to capture surface water movement.

Revealing pathways to escape losses or future potential yield

Multiple objectives can be attained by ensuring potential yield through abatement of post-harvest losses and developing the sustainable pathways (Vos andBellù, 2019).

Sustainingpest and disease resistant and food safety/biosecurity

The current system of agriculture is facing losses in fertility and production because of diseases, weeds and pests. Pathogens and pests of livestock and crops are evolving continuously and current protective measures are inevitable to synchronize productivity and gains. As chemical pesticides, herbicides and antimicrobials area serious threat to the environment and food purity, therefore, some other technologies are required not only to decrease consumption of chemicals but also to increase agricultural production. For this, various genetic modification approaches should be employed such as selective breeding and development of hybrid seed. Similarly, novel strategies for disease resistance involve the cloning and addition of exogenous genes and transferring them into genetic combinations of other crops to attain higher resistance against disease (Nekrasov *et al.,* 2017, Krattinger *et al.,* 2016 and Chen *et al.,* 2014). Genetically modified organisms technology is the only way to deal with the emerging challenges like climate change and biosecurity threats throughout the world. The commercial use of genetically modified organism technology is limited in most of the countries because of issues in adoption by the consumers and high cost of operation.

It is because of these trends that the commercial interest of the consumers has been renewed in non-GMO breeding techniques like gene editing that gives higher accuracy than GMO technology. Besides this, exogenous RNA interference is another technology to silent the desired genes in animals and plants. Fungal and viral diseases can be controlled by use of exogenous RNAi technique (Majumdar *et al.,* 2017 and Mitter *et al.,* 2017).Use of RNAi and herbicide together may result in more durable effect of chemicals and increased weed resistance. Integrated use of technologies and ecosystem actions is required to maintain the disease resistance of crops.

Extreme complexity is found in global supply chain of food and multiple biosecurity problems are paralleled with food safety problems. The focus should lie on the consideration of both animal and human health at same levels because numerous human diseases are originating from animal sources (Mi and Jeggo, 2016).Issues in food safety and biosecurity may result in trouble in the food supply chain due todirect impacts on public health.

In an era of globalization, food safety systems are interdependent because countries around the world cannot fulfill their food needs solely due to which universal food safety standards are required to be implemented which should be based upon scientific principles focusing on public health. Application of different technologies and their impacts on food safety has paved the way for paradigm shift and food safety is ensured accordingly.

Now it is trend to practice risk assessments to direct food safety standards and policy from prescriptive to target-oriented steps. New approaches for risk management i.e. Performance Objectives and Food Safety Objectives have been designed (Havinga and Verbruggen, 2017).The food industry becomes capable to deal with specific objectives with the help of aforementioned approaches and implementation the Hazard Analysis philosophy at Critical Control Points (HACCP) coupled with Good Hygienic Practices (GHP). Safety in the food supply is ensured with the help of this modern approach which provides scientific orientation to industry for the selection and implementation of control measures for specific operations (Scott, 2015).

It is the fact that many food safety measures are available which are stated by companies but still foodborne epidemics appear. Experienced management committed to maintain standards of food safety is required to improve the culture of food safety among employees (Nayak and Watersonm, 2017).Evaluation of audits for food safety and government interventions are the two major characters for reduction of risks involved in foodborne ailment (Taylor *et al.,* 2015).The governments both at national and international levels should support and indorse the culture for food safety through systematic supply chain.

Global trends like climate change, increasing population and the tendency to migrate from rural to urban areas have put new challenges and demands in front of the production and manufacturing sector whereas traders, venders and officials with respect to food safety is also facing the same. Globalization has made the accessibility of food easier but unfortunately with higher risk of foodborne diseases (Quested *et al.,* 2010).The antibiotic practices in food production while antimicrobial in preservation of food to enhance microbial resistance. Antibiotic resistant bacteria may be carried by food and can enter into the food chain easily (Capita and Alonso-Callejam, 2013).Maintenance of food safety will also be challenged by climate change, risks due to temperature changes and contamination during transportation (Tirado *et al.,* 2010).Developments in techniques and technologies such as gene sequencing, use of antimicrobials or natural anti-oxidants for food packaging, advances in tracking and tracing technologies, information communication technologies and improvement in immense data analyzing techniques carrying the potential to mitigate the threats and fulfill the demands (King *et al.,* 2017).

Evading water and soil degradation

Ground covering techniques and other production technologies to minimize nutrient runoff and erosion will be of paramount importance. Consumption of agro-chemicals and water will be reduced by precision agriculture to enhance production, meet demandand decrease losses. Prediction and adoption of climate forecasting technologies will be needed to increase global food production.

Degradation of soil brings down soils nutrient potential. Even land preparation techniques may result in infertility of soil. Development of nitrogen fixing within plants is an evolving approach to minimize fertilizer usage. For this approach, synthetic biology is used in manufacturing of nitrogenase for the mitochondria in plants (Allen *et al.,* 2017).But this approach requires further modifications and can be very beneficial in the forthcoming.

Mitigate climate effects and ensure food security

At present, global target is not set for alleviation of greenhouse gas emissions through agriculture. Calculations of latest research studies highlights that global warming can be limited to 2°C till 2100 and annual emissions from agriculture should be decreased down to 1 giga-tonne of CO^2 equivalents per year by 2030 (Wollenberg *et al.,* 2016).

Interventions available at present i.e. sustainable increase in dairy industry and alternative drying and wetting in irrigated rice will be essential for achieving emission efficiency. Yet these interventions are not sufficient to meet targets. Technical transformative options are required to be developed and implemented i.e. use of nitrogen inhibitors in crops, use of methane inhibitors in livestock and updated policies to enhance carbon sequestration of soil.

Adapting to unavoidable climate change

Climate change should not be avoided by farmers as they are being affected by itsimpacts and the necessity is to cope with changing effects (Abdullah*et al.,* 2016).Various studies have shown that by making changes in production techniques, impacts of climate change can be mitigated (Robertson *et al.,* 2016).The approaches like efficient use of radiation, increased photosynthetic potential and modified canopy construction can be utilized to upsurge yield potential (Parry *et al.,* 2011 and Rebetzke *et al.,* 2013).

Perspectives on social challenges

Although different technical solutions may be provided by scientific approaches but the stakeholders are needed to pay attention to consumer, market and social challenges to adopt them. The upcoming research strategies should consist upon new processes to evaluate innovations according to social values (Feldt *et al.,* 2013).The point of discussion among people around the world should revolve around principled trade-off, consideration among social decisions for food selection to attain sufficient nutrition coupled with sustainable environment (Fanzo, 2015).Sustainable food security among masses can be ensured by affecting consumer behavior for choice of foods with meagre environmental effects, consumption of proper food to come across nutritional requirements and decrease the food losses (Alexander *et al.,* 2017).

Multidisciplinary effort to cope with food and nutrition security

Multidisciplinary approach like the integration of agriculture, economics and social sciences are needed to find collective solutions for food security maintenance globally (Qaim, 2017). It is also necessary to know how advances in other disciplines may effect food security. A cohesive multidisciplinary approach is needed through different lines of analysis to ensure sustainable food security (Horton *et al.,* 2017). Food ecosystem should be considered entirely to address food security. Social, institutional and ecological methods are essential due to complex farming systems at several scales (Witt man *et al.,* 2017).

Collaborative and trans-disciplinary approach may be used for the collective and systematic initiative for food and nutrition globally and this will brighten the social, market and other mega trends (Lamine*et al.,* 2019).

Conclusion

The complexity of food security needs proper attention involving both planetary and human health. Trans-disciplinary research and technological innovations along with integrated system of interventions is needed to be applied. Global megatrends will influence the above mentioned efforts. A version of wedges framework has been considered by the Food Security Committee of IUFST (International Union of Food Science and Technology) that may reflect value chain of food. Furthermore, it will be effective to reform the framework in order to maintain demand and balance of nutrients for human health. On the basis of the discussed perspective and approaches, it is expected that they will enable the current system to generate proper coordination among disciplines and to provide means to express relative impact of an innovation in food security. Lastly, the recommendations and output of the current study might provide directions to policy drivers and other stakeholders.

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